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Original Communication

Injuries to neck structures in deaths due to constriction of neck, with a special reference to hanging

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Abstract

This prospective study aimed at examining various injuries to the neck structures in deaths due to constriction of neck. Neck dissection technique, as advocated by Prinsloo and Gordon was undertaken to study the injuries to the thyro-hyoid complex, strap muscles, carotid vessels, etc.

Of the 1746 medico-legal autopsies, conducted during the study period, 5% were deaths due asphyxia of which 82% were those of constriction of neck. The 21–30 years age group accounted for the maximum number of cases (57%). Male:female ratio was 2:1. Hanging (69%) outnumbered other asphyxial deaths – ligature and/or manual strangulation, smothering, etc. Injury to the sternocleido-mastoid muscle (54%) was the commonest injury to the neck structures. The hyoid bone was fractured in 21% cases, while the thyroid cartilage was fractured in 17% cases. Complete hanging was noted in 68% of cases while the hanging was atypical in 88%. Fixed knot was found to have been used in 71%. A single loop round the neck was observed in 80% of the cases and it was above the level of thyroid in 58% cases. Most cases of the fracture of the laryngo-hyoid complex were in the 41–60 year age group, 72% and the fracture was on the same side as the knot in 52% cases. Majority used soft daily wear articles of clothing like a sari (32%) or chunni (24%).

Asphyxial deaths due to constriction of neck being common in all parts of the world, prospective studies in different setups to examine the profile of neck structure injuries are needed so as to differentiate the suicidal or homicidal nature of such deaths with a greater certainty.

Keywords: Asphyxia; Asphyxial deaths; Hanging; Strangulation; Ligature; Laryngo-hyoid complex; Medico-legal autopsy

1. Introduction

The term 'asphyxia' literally means 'defective aeration of blood' due to any cause. Bacroft[1] using the term 'anoxia' divided the condition into three groups: (1) anoxic anoxia – meaning prevention of oxygen from reaching the lungs, (2) anemic anoxia – meaning inability of blood to carry sufficient oxygen to the tissues due low hemoglobin content, and (3) stagnant anoxia – meaning lack of oxygenated blood transport to the tissues due to impaired circulation. Later on, Peters and Van Slyke in 1931 added a fourth group to it called histotoxic anoxia – wherein, though freely available in the blood stream, oxygen cannot be utilized by the tissues.[2] The 'histotoxic anoxia' was further divided into (1) extra-cellular depicting a fault at the tissue oxygen enzyme system, as for example, in cyanide poisoning, (2) peri-cellular depicting that oxygen cannot gain access to the cell because of decreased cell membrane permeability as is seen in lipoid soluble anesthetic agents like halogenated hydrocarbons, (3) substrate – meaning inefficient metabolism by the cell on account of inadequate

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energy (food), and (4) metabolite – where end products of the cellular respiration cannot be removed thereby preventing further metabolism as in uremia or CO_2 poisoning.

Adelson[3] defined 'asphyxia' as the physiological and chemical state in a living organism in which acute lack of oxygen available for cell metabolism is associated with inability to eliminate excess of CO_2. Despite the differences of opinion regarding the term 'asphyxia' in medical literature, it is widely used for medico-legal purposes and is categorized as 'mechanical asphyxia' – meaning that the flow of air into the body is interfered through some physical impediments, and 'non-mechanical asphyxia' – taken to mean physiological impediments where there occurs exclusion of oxygen by its depletion and replacement by another gas or by chemical interference with its uptake and utilization by the body itself or where there is insufficient oxygen in the atmosphere itself.

Asphyxial deaths may be caused by different methods, such as hanging, strangulations (manual and ligature), suffocations (environmental, smothering, choking, mechanical, and suffocating gases), chemical asphyxia (carbon monoxide CO, hydrogen cyanide, and hydrogen sulfide), and drownings.[4] Additionally, in some cases, the victim dies as a result of the combination of different mechanisms of asphyxia. A case study from Romania[5] indicates that a victim was killed by three different mechanisms of asphyxia: smothering with the hand, manual strangulation with the other hand, and traumatic asphyxia by thoracic compression with the knees. Autoerotic asphyxial deaths,[6–9] positional asphyxial deaths,[10,11] and neck holds[12] are some other reported unusual forms of asphyxial deaths in forensic practice.

Asphyxial death is a common incident in forensic practice, and determination of the manner of death that may be accidental, suicidal, homicidal, or natural is of utmost significance. In such deaths, a detailed and meticulous autopsy plays a major role to solve the case while the scene investigation and collection of samples have their own significance.[4] The purpose of this study was to investigate some features of asphyxial deaths in the Chandigarh region of Northern India and to compare them with other studies.

2. Materials and methodology

This prospective study was conducted at the Department of Forensic Medicine and Toxicology, Government Medical College Hospital, Chandigarh, during the period from January 2001 to December 2005. Ninety-five cases of deaths due to asphyxia subjected to medico-legal autopsy were the subjects of the study. The information regarding identification of the deceased and the type of asphyxial death was obtained from the police and detailed interviews of the relatives of the deceased. Various injuries to the neck structures in different cases of compression of the neck (hanging, ligature strangulation, manual strangulation/throttling) and the different types of hanging were carefully noted at the time of conducting the autopsy using a standardized technique that included specific attention to the ligature mark on the neck, a layered dissection of the neck tissues and careful assessment of other injuries on the body surface.

Neck dissection was undertaken after evisceration of the other body organs, following the protocol of Prinsloo and Gordon (a layer by layer dissection of the neck with the first incision being immediately deep to the skin, through the platysma and inspection of each layer before dissection. The thyroid gland is exposed by blunt dissection, and the larynx, trachea, pharynx and esophagus are mobilized and dissected for thorough inspection).[13] In this way careful attention to the soft tissues of the neck could be made, thereby defining the presence of internal neck injury. The type of injuries that were specifically sought included bruises of the thyroid capsule or gland, injuries to the thyro-hyoid membrane, bruises of the soft tissue or strap musculature, intimal injury in one of the carotid arteries and laryngeal fracture (hyoid bone and/or thyroid cartilage and/or cricoid cartilage).

Blood samples taken from the left chamber of the heart and tissue samples were collected for systemic toxicological analysis according to regular procedures. All samples were sent to the Forensic Science Laboratory/Chemical analyzer to determine/rule out use of drugs, poison, and ethanol. Histopathological examinations of all cases were done at the Department of Pathology. The data so obtained from detailed history, postmortem examination, chemical analysis and histopathological examination was analyzed and compiled.

3. Results

A total of 1746 medico-legal autopsies were conducted during the period under study, of which 95 (5%) were asphyxial deaths. Male victims (63) were twice the number of female victims (32). Considering the asphyxial deaths in general, hanging was the commonest mode observed in 66 (69%) cases, followed by drowning in 10 (11%) (Fig. 1).

The age group 21–30 years, accounted for the maximum number of cases, 54 (57%), followed by the age group 31–40 years, 15 (16%) cases. Extremes of age, the less than 15 years and the more than 60 years groups, comprised 2% victims, each (Fig. 2).

Among the different cases of death due to constriction of neck, injury to the sternocleido-mastoid and other muscles was the commonest injury observed in the 33 (42%), followed by the fracture of the hyoid bone, 16 (21%) cases (Table 1).

Among those having fracture of the hyoid bone, fracture of the left greater horn was more common, 11 (69%) cases. As regards the fracture of different parts of the hyoid bone in different forms of constriction of neck, it was noted that fracture left lesser horn was more common, nine (14%) followed by the fractures of left greater and right lesser horns, eight (12%) each in cases of hanging; while left greater horn was found fractured more commonly in ligature strangula-

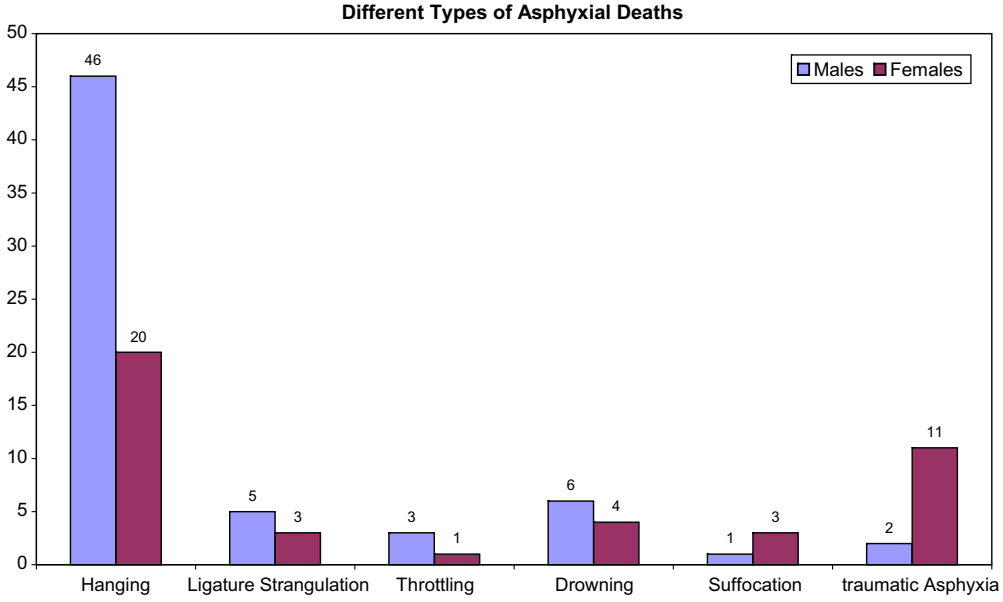

Fig. 1. Different types of asphyxial deaths.

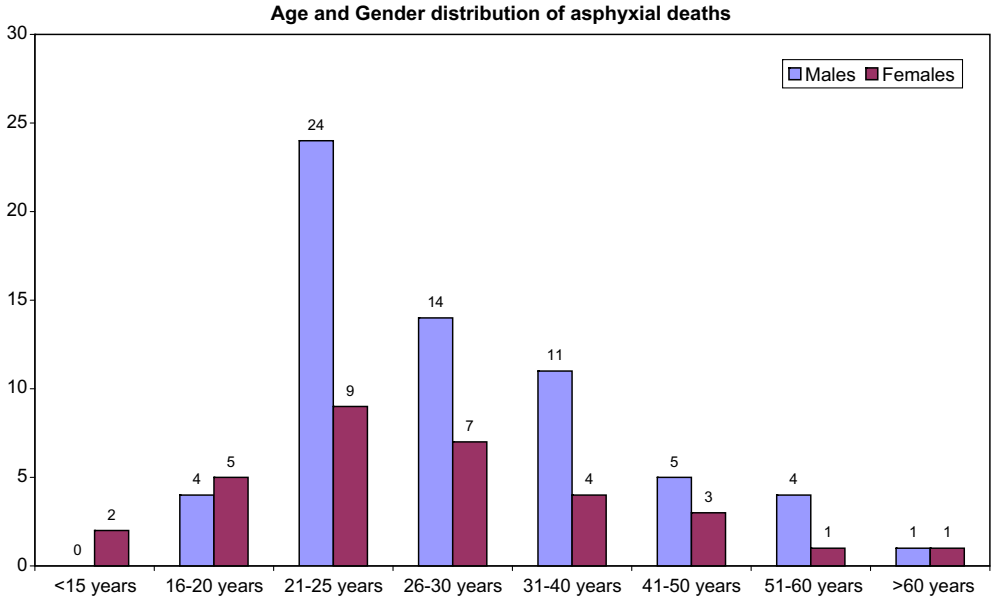

Fig. 2. Age and gender distribution of asphyxial deaths.

tion, two (67%) and right greater horn in cases of throttling, two (67%) (Table 1).

Among the injuries to the thyroid cartilage, bruising of the capsule was found in seven (11%) cases of hanging and four (100%) cases of throttling while both bruising of the capsule in association with the fracture of the body were found in four (50%) cases of ligature strangulation. Fracture of the body of thyroid cartilage was found in six (9%) cases of hanging and three (75%) cases of throttling (Table 1).

Overall, 45 (68%) cases were of complete hanging and 58 (88%) cases were of atypical hanging (suspension point being at a place other than the nape of neck, as against the typical hanging – having suspension point at the nape of neck as seen in judicial hanging in India).

Petechiae were observed in a total of 28 (42%) cases of which 21 (75%) were of incomplete hanging and seven (25%) were atypical complete hanging. However, petechial hemorrhages were not found in either ligature or manual strangulation (Tables 1 and 2).

Considering the neck structure injuries in different types of hanging, it was observed that injury to the sternocleidomastoid and other muscles was more common in cases of typical and complete hanging, three (60%), while fracture right superior horn of hyoid bone was the more common injury in cases of typical and incomplete hanging, two

Table 1
Neck structure injuries in cases of compression of neck

Neck structure injuries	Compression of neck							
	Hanging ($n = 66$)		Ligature strangulation ($n = 08$)		Throttling ($n = 04$)		Total ($n = 78$)	
	No.	%	No.	%	No.	%	No.	%
Injury to hyoid bone ($n = 16$)								
# Hyoid bone	10	15.2	3	37.5	3	75.0	16	20.5
# Left greater horn of hyoid bone	8	12.1	2	25.0	1	25.0	11	14.1
# Right greater horn of hyoid bone	6	9.1	1	12.5	2	50.0	9	11.5
# Left lesser horn of hyoid bone	9	14.1	0	0	1	25.0	10	12.8
# Right lesser horn of hyoid bone	8	12.1	0	0	0	0	8	10.3
Injury to thyroid cartilage ($n = 15$)								
# Body of thyroid cartilage	6	9.1	4	50.0	3	75.0	13	16.7
# Superior horn of thyroid cartilage	2	3.0	1	12.5	2	50.0	5	6.4
Bruising of the thyroid capsule	7	10.6	4	50.0	4	100.0	15	19.2
Injury to muscles and vessels								
Injury to sternocleido-mastoid and other muscles	28	42.4	4	50.0	1	25.0	33	42.3
Injury to blood vessels	6	9.1	2	25.0	0	0	8	10.3
Petechial hemorrhages	28	42.4	0	0	0	0	28	35.9

Table 2
Neck structure injuries in different types of hanging

Neck structure injuries	Types of hanging				
	Typical complete ($n = 05$) No.	Typical incomplete ($n = 03$) No.	Atypical complete ($n = 40$) No.	Atypical incomplete ($n = 18$) No.	Total ($n = 66$) No.
Injury to hyoid bone					
# Body of hyoid bone	1	2	5	2	10
# Left greater horn of hyoid bone	1	0	4	2	7
# Right greater horn of hyoid bone	0	0	5	1	6
# Left lesser horn of hyoid bone	1	1	5	2	9
# Right lesser horn of hyoid bone	0	2	4	2	8
Injury to thyroid cartilage					
Bruising of thyroid capsule	1	0	5	1	7
# Superior horn of thyroid cartilage	0	0	1	1	2
# Body of thyroid cartilage	1	0	4	1	6
Injury to muscles and vessels					
Injury to sternocleido-mastoid and other muscles	3	1	16	8	28
Injury to blood vessels	0	0	6	2	8
Petechial hemorrhages	0	3	7	18	28

(67%). Again, injury to the sternocleido-mastoid and other muscles was found to be more common in atypical and complete 16 (40%) as well as atypical and incomplete hanging eight (44%) cases (Table 2).

Sari was the commonest ligature material used by the males, 14 (30%), while females preferred chunni nine (45%) followed by the sari seven (35%). In 53 (80%) cases a single loop around the neck was noted while the ratio of single:multiple loops was 3.6:1 for males and 5.7:1 for females (Fig. 3).

Slipknot was found in 19 (29%) cases of hanging and 'fixed-knot' in the rest. The knot was more often placed in the right posterior aspect of the neck, 21 (32%) cases. The ligature mark was above the level of the thyroid in 38 (58%) cases. In cases of both the 'slip knot' and the 'fixed knot', the hanging was mostly atypical and complete, 15 (79%) and 25 (53%), respectively, implying thereby that the hanging was more often 'atypical and complete' 40 (61%) (Table 3).

The laryngo-hyoid complex was fractured in 25 (33%) of the total 78 cases, maximum cases belonged to the age group 41–60 years, 18 (72%), followed by the 21–40 years age group, four (16%). The male:female ratio was 2.5:1. The fracture was on the same side as the knot in 13 (52%) cases, opposite side in 10 (40%), and both sides in two (8%) cases. The hyoid bone alone was involved in 12 (48%) cases, thyroid cartilage in nine (36%) while both were involved in four (16%) cases (Table 4).

On chemical analysis and histopathological examination, nothing specific/contributing towards death was

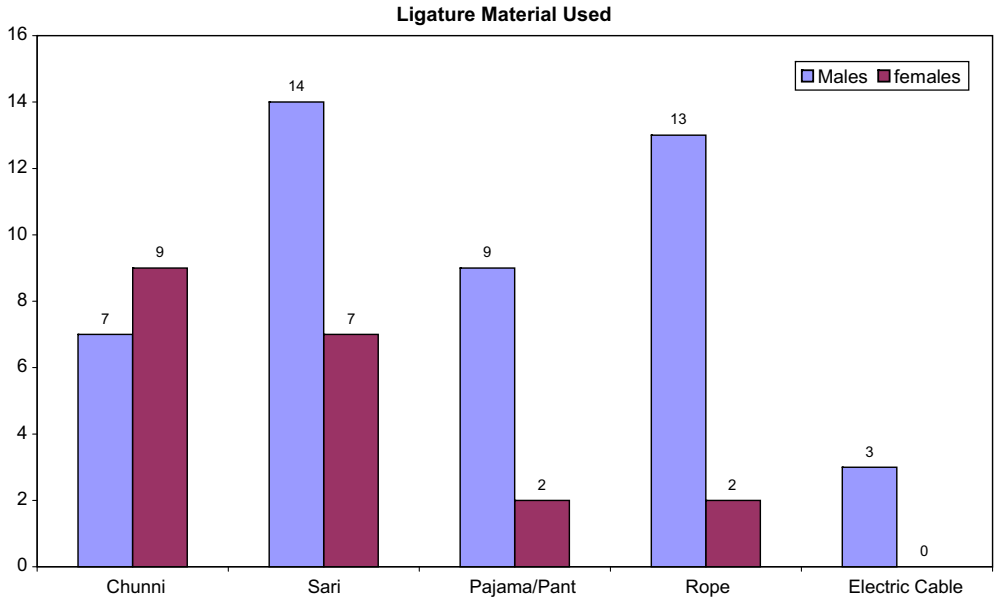

Fig. 3. Ligature material used.

Table 3
Relationship of the type of knot to the position of the knot and the type of hanging

Position of the knot	Type of the knot					
	Slip knot ($n = 19$)		Fixed knot ($n = 47$)		Total ($n = 66$)	
	No.	%	No.	%	No.	%
Side of the neck						
Right side (anteriorly)	3	15.8	7	14.9	10	15.2
Left side (anteriorly)	4	21.0	12	25.5	16	24.2
Right side (posteriorly)	5	26.3	16	34.0	21	31.8
Left side (posteriorly)	7	36.8	12	25.5	19	28.8
Level on the neck						
Above the thyroid cartilage	11	57.9	27	57.5	38	57.6
At the level of the thyroid	5	26.3	13	27.7	18	27.3
Below the thyroid cartilage	3	15.8	7	14.9	10	15.2
Type of hanging						
Typical complete	3	15.8	2	4.3	5	7.8
Typical incomplete	0	0	3	6.4	3	4.5
Atypical complete	15	79.0	25	53.2	40	60.6
Atypical incomplete	1	5.3	17	36.2	18	27.3

found in all the cases except the detection of alcohol in eight (16%) male victims.

4. Discussion

Asphyxial deaths are caused by the failure of cells to receive and/or use oxygen.[4] Brain is most sensitive to oxygen deprivation, and it is the organ mostly affected in all types of asphyxial death. However, cardiac function usually continues for several minutes after respiratory arrest.[12]

Petechiae are commonly recognized as a fundamental, albeit non-specific, feature of asphyxiation. Their mechanism of formation is problematic, but focal extravasation may result from a combination of elevated venous pressure and hypoxic injury to endothelial cells. In this series of 95 asphyxial deaths, external and internal petechiae were seen with an overall prevalence of 42%, most commonly on or around the eyes. The nature of the ligature knot, whether a slipknot or fixed knot made little difference to this figure. This is in contrast with Davison and Marshall[14] who suggested that a fixed knot, resulting as it may in incomplete constriction of the neck, may be expected to result in more facial petechiae than a slipknot. Other series have reported the incidence of petechiae as between 10%[15] and 68%.[16] If the figures of four published series that specifically address this point are combined, then out of a total of 311 cases, external petechiae were seen in 90 (29%).[10,14,17,18] In each of these series was the observation that petechiae were

Table 4
Particulars of laryngo-hyoid complex fractures

Particulars	No.	%
Age in years		
<20	0	0
21–40	4	16.0
41–60	18	72.0
>61	3	12.0
Total	25	100 (32.0)
Sex		
Male	18	72.0
Female	7	28.0
Position of knot (on the side of neck)		
Ipsilateral	13	52.0
Contralateral	10	40.0
Bilateral	2	08.0
Structures involved		
Thyroid cartilage	9	36.0
Hyoid bone	12	48.0
Thyroid–hyoid combined	4	16.0

more frequently seen when suspension was not complete, a comment confirmed in this series with external petechiae in 75% of those incompletely suspended compared with 25% of those completely suspended. Emphasizing this point further, Luke et al.[17] noted a direct correlation existing between the extent of body support and the likelihood of finding petechiae, a finding confirmed by us with the highest percentage being in those who were kneeling or sitting (59%). However, complete absence of petechiae has been reported in five of 48 cases even in homicidal strangulation by ligature without further discussion of the conditions explaining this.[19]

A ligature mark to the skin of the neck was present in 98% of the cases, about the same as seen by others.[16,17] Mostly the mark, in cases of hanging, crossed the midline of the front of the neck above the laryngeal prominence in 58% cases, in agreement with others.[14,17,20] Luke et al.,[17] described the high position of the ligature as a factor in the likelihood of laryngeal fracture, but the association has been denied by others.[20] It has been reported that when the ligature mark was narrow, there was a much greater likelihood of laryngeal fracture, probably reflecting greater force per unit of surface area with a narrow ligature,[21] however, we could not confirm the observation. In a minority of cases there was indication of movement of the ligature over the skin of the neck, as evidenced by the presence of a slipping abrasion of the skin. As might be expected, this finding was more likely to be seen with complete suspension than with incomplete suspension.

In 29% of the cases when a knot was described it was of the 'slip-type', forming a running noose, in general agreement with other workers.[14,22] However, irrespective of the type of knot, the prevalence of internal neck injury was much the same, being seen in 58% of those with a slip knot and 60% of those with a fixed knot. In 53% cases the knot was located on left side of the neck; there was however, no correlation with location of a laryngeal fracture, with 52% cases having ipsilateral fracture and 40% cases having a contralateral fracture. In 8% cases, bilateral laryngeal fractures were present. It would appear then that no useful comment can be made about the type or location of a ligature knot from an isolated consideration of the internal neck injuries.

Of the 78 cases of deaths due to constriction of neck in this series, injury to the laryngo-hyoid complex was seen in 25 (32%). There is close similarity between our results and those of Simenson[23] who demonstrated fracture of the thyroid cartilage in 37% of cases (12% of the total and 36% of those having laryngo-hyoid complex injury in our series), fracture of the hyoid bone in 9% of cases (14% of the total and 48% of those having laryngo-hyoid complex injury in our series) and a fracture of both hyoid bone and thyroid cartilage in 9% of cases (5% of the total and 16% of those having laryngo-hyoid complex injury in our series). The other series give more widely disparate results; there is some consistency however in the rate of hyoid bone fracture (generally around 10%), with a generally greater prevalence of thyroid cartilage fracture. In two series[22,23] no laryngeal injury was demonstrated in any of the cases. Bowen's series[24] was an apparently retrospective analysis of 201 cases; he mentions, "... no fractures of the laryngeal cartilage", which we interpret to mean the thyroid cartilage being uninjured. Specific mention of the other structures including the hyoid bone is not made. It appears likely that the absence of fracture in any of these cases reflects the retrospective nature of the study. Elfawal and Awad's series from Saudi Arabia[22] was of 61 cases, apparently studied prospectively, in which no injury was demonstrated. There was no ready explanation for this finding. The absence of injury seems particularly unusual as the majority of the cases were completely suspended (48 of the 61 cases) and many were older than 40 years of age (13 of the 61 cases).

We found a greater proportion of males to have laryngeal injury 33% (eight out of 54) than females 29% (seven out of 24), a difference not explained by a gender difference in the degree of suspension. It is possible that the difference is a consequence of greater plasticity of the female throat structures.[13] Simenson[23] agrees with this gender difference, with 52% of males of his series having a laryngeal fracture, compared with 34% of the females. Paparo and Siegel however, found that fractures were at least twice as common in females, this difference being more significant in the retrospective component of their series.[20]

We noted a greater prevalence of laryngeal injury in those over the age of 40 years, irrespective of the degree of suspension (incomplete 58% compared with 28% for those less than 40 years; complete 75% compared with 44% for those less than 40 years). Luke et al.,[17] reported a similar age-related increase in prevalence of laryngeal injury, particularly for those who were incompletely suspended (50% injury rate for those over the age of 40, compared with 10% for those less than 40 years). In their combined retrospective and prospective series, Paparo

and Siege[20] had a similar finding with 26% of those over 40 years having laryngeal injury, compared with 10% for those less than 40 years. Simenson was the most recent worker to confirm this trend,[23] with 52% of those over 40 years having laryngeal injury, compared with 34% for those less than 40 years. There was no age-related difference in the degree of suspension or type of ligature in our series in conformity wiht O'Halloran and Lundy[25]. Presumably then, the difference in rate of laryngeal injury between these two age groups reflects increasing brittleness of the laryngeal structures with increasing age.[26,27]

We found a greater incidence of fracture of the body of thyroid (17%), as compared to the fractures of superior horn (6%). This comparatively unusual finding in our study could be attributed to the type of ligature material used for hanging – sarees and chunnis, both being soft material capable of producing a broad ligature and as such exerting the pressure on neck structures in a manner different from that produced on a narrow ligature.

Few of the reviews[14–22,28] have specifically addressed the question of the presence of other injuries on the body. In our study, fresh injuries to the body surface (excluding those of medical intervention) were present in 2% of cases, the majority being fresh-appearing injuries. Davison and Marshall[14] reported that such injuries are seen "occasionally". They found multiple blunt force superficial injuries in three cases, fresh-appearing, self-inflicted wounds in two cases, incisions on the fronts of the wrists in five and penetrating (stab) injuries to the chest and abdomen in a further one case. Other workers have similarly commented on the unusual nature of such self-inflicted injuries in hanging deaths.[16,26]

Paparo and Siege[20] noted that retrospective collection of data cannot be entirely relied upon. This view is reinforced by our earlier study[29] because each of the factors specifically examined for in the prospective study may be reported with less frequency in the retrospective group of cases. In some cases there may be a disturbing lack of specificity regarding the presence or absence of injury, and its nature if present. Accordingly, studies of this type require not only prospective collection of data but also pre-study standardization of dissection technique, particularly where there is involvement of different prosecutors. Furthermore, the physical forces involved in hanging depend to an extent on the size and weight of the body, the completeness or otherwise of the drop, the age and sex of the deceased – which have a bearing on the degree of calcification or otherwise on bony components, and therefore the brittleness of the neck structures, the restrictions of space where the hanging took place and the intrusion into this space of other objects and so on also need to be taken into consideration.

5. Conclusion

A careful forensic examination in asphyxia involving pressure on the neck with ligature material is of great importance, even in the case of hanging supposed to be suicidal, with the aim of ascertaining the antemortem character of the lesion and the physio-pathological mechanism of death and to exclude the possibility of murder dissimulation. Furthermore, the ligature mark being mainly a postmortem phenomenon, any inner neck structure injury indicating ligature mark intravitality is to be identified to establish the antemortem hanging. However, a critical analysis of the postmortem diagnostic criteria for asphyxia leads to a difficulty that has significant implications for the forensic pathologist. The difficulty is that there are no universally recognized pathognomic signs of asphyxia and the pathologists frequently make this diagnosis based on observations that individually have indeterminate significance but combined together, in the appropriate context, have diagnostic value. Still-further, the signs of strangulation form a spectrum of degree from minimal to marked and there is no consensus as to the minimal number and nature of lesions that is required to make the diagnosis of strangulation. There are occasions when the injury to the neck structures caused by hanging or ligature strangulation may become difficult to appreciate for the doctor conducting autopsy and as such there is need for studies in different setups to examine the profile of neck structure injuries so as to differentiate the suicidal or homicidal nature of such deaths with a greater certainty.

References

1. Bacroft J. Physiological effects of insufficient oxygen supply. *Nature* 1920;**106**:127.
2. Peters JP, Van Slyke DD. *Quantitative clinical chemistry*, vol. 1. Baltimore: Williams and Wilkins; 1931. p. 539–661.
3. Adelson L. *The pathology of homicide*. Springfield: Charles C Thomas; 1974. p. 555–7.
4. DiMaio DJ, DiMaio VJM. *Asphyxia. Forensic pathology*. Boca Raton (FL): CRC Press; 1993. p. 207–51.
5. Lupascu C, Lupascu C, Beldiman D. Mechanical asphyxia by three different mechanisms. *Legal Med* 2003;**5**:110–1.
6. Tournel G, Hubert N, Rouge C. Complete autoerotic asphyxiation: suicide or accident? *Am J Forensic Med Pathol* 2001;**22**:180–3.
7. Gosink PD, Jumbelic IM. Autoerotic asphyxiation in a female. *Am J Forensic Med Pathol* 2000;**21**:114–8.
8. Uva JL. Review of autoerotic asphyxiation in the United States. *J Forensic Sci* 1995;**40**:574–81.
9. Breitmeier D, Mansouri F, Albrecht K. Accidental autoerotic deaths between 1978 and 1997. *Forensic Sci Int* 2003;**137**:41–4.
10. Madea B. Death in a head-down position. *Forensic Sci Int* 1993;**61**:119–32.
11. Belviso M, De Donno A, Vitale L. Positional asphyxia: reflection on 2 cases. *Am J Forensic Med Pathol* 2003;**24**:292–7.
12. Spitz WU, Fisher RS. *Medicolegal investigation of death*. 3rd ed. Springfield (IL): Charles C Thomas; 1993. p. 444–98.
13. Prinsloo I, Gordon I. Post-mortem dissection artefacts of the neck: their differentiation from ante-mortem bruises. *SA Med J* 1951;**25**(21):358–61.
14. Davison A, Marshall TK. Hanging in Northern Ireland – a survey. *Med Sci Law* 1986;**26**:23–8.
15. Guarner J, Hanzlick R. Suicide by hanging – a review of 56 cases. *Am J Forensic Med Path* 1987;**8**:23–6.
16. Luke JL. Asphyxial deaths by hanging in New York City, 1964–1965. *J Forensic Sci* 1967;**12**:359–69.

17. Luke JL, Reay DT, Eisele JW. Correlation of circumstances with pathological findings in asphyxial deaths by hanging: a prospective study of 61 cases from Seatle, WA. *J Forensic Sci* 1985;**30**:1140–7.
18. James R, Silcocks P. Suicidal hanging in Cardiff – a 15-year retrospective study. *Forensic Sci Int* 1992;**56**:167–75.
19. DiMaio VJM. Homicidal asphyxia. *Am J Forensic Med Pathol* 2000;**21**:1–4.
20. Paparo GP, Siegel H. Neck markings and fractures in suicidal hanging. *Forensic Sci Int* 1984;**24**:27–35.
21. Maxeiner H. Hidden laryngeal injuries in strangulation: how to detect and interpret these finding. *J Forensic Sci* 1998;**43**:784–91.
22. Elfawal MA, Awad OA. Deaths from hanging in the Eastern Province of Saudi Arabia. *Med Sci Law* 1994;**34**:307–12.
23. Simenson J. Patho-anatomic findings in neck structures in asphyxiation due to hanging: a survey of 80 cases. *Forensic Sci Int* 1988;**38**:83–91.
24. Bowen DA. Hanging – a review. *Forensic Sci Int* 1982;**20**:247–9.
25. O'Halloran RL, Lundy JK. Age and ossification of the hyoid bone: forensic implications. *J Forensic Sci* 1987;**32**:1655–9.
26. Maeda H, Imura M, Higuchi T, Noguchi K. Case report: an autopsy case of suicide by hanging with multiple stab wounds of the neck and chest. *Med Sci Law* 1993;**33**:67–9.
27. Vanezis P. *Pathology of neck injury*. Butterworth and Co; 1989. p. 75.
28. Pounder DJ. Why are the British hanging themselves? *Am J Forensic Med Path* 1993;**14**:135–40.
29. Sharma BR, Singh VP, Harish D. Neck structure injuries in hanging – comparing retrospective and prospective studies. *Med Sci Law* 2005;**45**(4):321–30.